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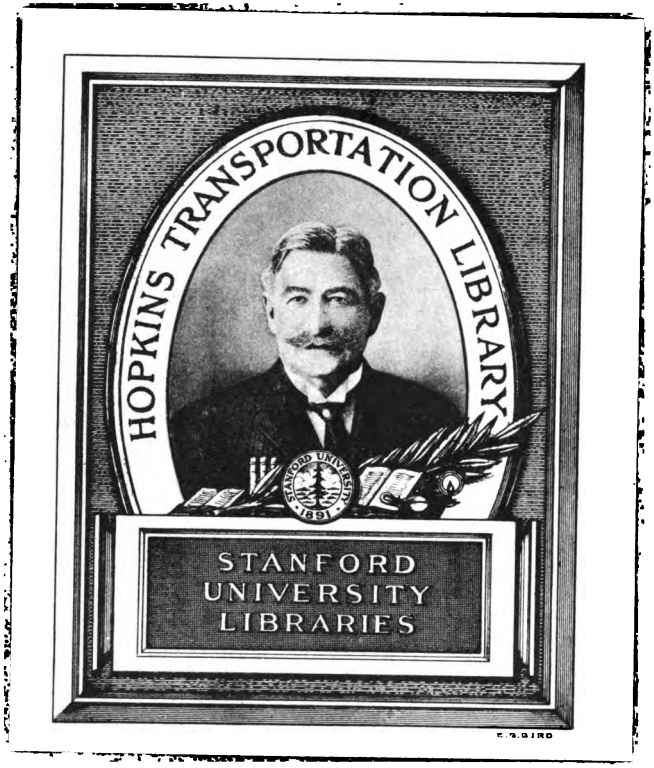

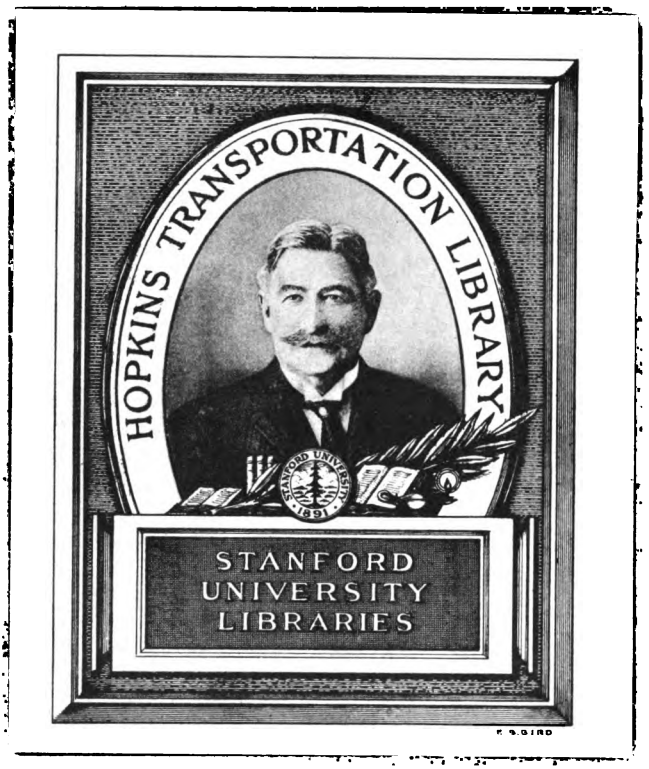

ACCOUNT

OF THE

STEAM-FERRY OVER THE RIVER NILE,

AT KAFFRE AZZAYAT.

By THOMAS SOPWITH, M. Inst. C.E.

WITH AN ABSTRACT OF THE DISCUSSION UPON THE PAPER.

EDITED BY

CHARLES MANBY, F.R.S., M. Inst. C.E.
SECRETARY.

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in the Chair.

No. 975.—"Account of the Steam-ferry over the River Nile, at Kaffre Azzayat." By THOMAS SOPWITH, M. Inst. C.E.

DURING a visit to Egypt, in the winter of 1856-7, the Author had an opportunity of travelling on the first Egyptian railway, and of examining the remarkable Steam-ferry, by which the railway-trains are conveyed from Kaffre Lais to Kaffre Azzayat, —towns so called on the opposite banks of the River Nile, and situated about midway between Alexandria and Cairo.

To any one who visits Egypt for the first time, the subjects which present themselves are curious and impressive,—suggestive, on the one hand, of ages long passed away, and on the other of rapid and cheering progress in civilization and the arts. "The Land of Egypt" is associated with the earliest lessons of childhood, and these are so fixed in the mind, with patriarchal imagery and oriental scenery, that the very idea of a railway, a ferry, or any other work of modern engineering, seems inconsistent with all anticipations, in that remarkable country.

The chief object of this Paper is to describe the ferry across the River Nile; but it may not be without interest to the Members of this Institution, to endeavour to carry them, as it were, by description, along the first-made African railway; so that approaching, in this way, the locality of the ferry, they may be enabled to understand its general appearance and mode of operation, in the same manner that it came under the observation of the Author, when he visited the spot with Mr. R. Stephenson, M.P., President, by whom it was designed, and at whose works, at Newcastle-upon-Tyne, the several parts of the structure were manufactured, which were afterwards fitted together on the Nile, by Mr. Edward Price (Assoc. Inst. C.E.), the Contractor for the railway.

On the morning of Dec. 17th, 1857, the Author accompanied Mr. Robert Stephenson, Mr. Rouse, and other gentlemen connected with the railway, on an excursion from Alexandria. On landing at the railway-pier in that city, he was astonished by the singular aspect of the railway-works. Vast numbers of the Arab natives were employed, some in carrying coals and other materials, others in laying a branch railway with Greaves' semi-

spheroidal chairs; whilst swarms,—for no other word conveys the idea,—were excavating mounds of earth with small hoes, the only implements they use, and which they apply with great dexterity and success, to almost every kind of earth-work. With these hoes they rapidly fill loose baskets of matting, and hand them over to boys, who convey them to convenient places of deposit. The extraordinary concourse of people at the station was a sight never to be forgotten. First were the native labourers, running about with cat-like activity and security, ever escaping with marvellous facility from, apparently, the most dangerous positions. This peculiar facility of movement will be again noticed, when the method of adjusting the railway platform of the steam-ferry is described. The power of endurance of fatigue in long-continued running, or other violent exercise, is only equalled by their natural tendency to repose when circumstances permit. They can keep up with a horse for a whole day, going 30 or 40 miles, at a moderate speed; and in this, and other illustrations of active labour, such as running before carriages in the streets, a condition of strength is combined with agility and freedom of movement, very different from what can be seen in the labourers of Western Europe. But not to dwell on this, further than as bearing on railway labour, it may be observed, that the Oriental dress is well adapted, as well for a complete development of the figure, as for freedom of muscular exertion. The loose and flowing robes of an Arab sometimes remind an English spectator of the finest figure draperies of Raphael: these are, in a great measure, thrown aside, or worn loosely, during hot weather, or when the wearer is actively occupied; but when the hour of rest, or the coolness of evening arrives,—his robe, being closely wrapped around him, promotes warmth. Scores of labourers, thus resting, are to be found near the steam-ferry: as the train approaches, they immediately rise, and, with great facility, make all the needful adjustments.

The railway excavations in Egypt have a peculiar antiquarian interest. In many places, and particularly near Alexandria, no sooner is the superficial soil and sand of recent accumulations removed, than the excavator is in the midst of ruins, or caves, of a world of some two, or three thousand years ago, and his labours are lightened, now and then, by the discovery of long-buried relics of the past. The associations which they present to the mind are as remote as the period when Alexandria, in its former greatness and glory, was one of the chief emporiums of trade, the seat of learning, and a city of vast magnitude and splendour.[1]

[1] Some of the urns and lamps found at the time of this visit were exhibited, and a fine Roman vase, containing human bones, which was dug up, when Mr. R. Stephenson was present. Many of the excavations are shown in a series of photographic pictures by Mr. F. R. Lee, R.A.

The assemblage of passengers at the station was very great, and included, as may be supposed, persons of different nations, a variety of costume, a very Babel of tongues, and a number of the humblest class of passengers. So great indeed was the rush for places by the Arab population, for some months after the opening of the railway, that the carriages provided could not contain all of them, though they climbed to the top, and hung on to the sides and ends of the carriages and trucks, as well as being closely packed in the interior. Nine o'clock was the hour of departure (then, on alternate days—now daily), and for three, or four hours before that time, crowds were resting at the door of the station, to obtain early admission. This avidity for railway transit exceeds anything that has been witnessed in England, as regards the masses of people travelling by ordinary trains.

It is not necessary to describe the line of 65 miles of railway by which the ferry is approached. But considering how important a link of communication it forms, being situated midway between Great Britain and her Indian Empire,—considering also the extreme peculiarity of such an innovation on habits of travelling, which otherwise had remained unchanged since the wanderings of the Israelites, and viewing it as the first railway yet made out of the limits of Christian civilization, it is impossible to travel along such a line for the first time, without being deeply impressed with the significance of such an improvement, and with the world-wide character of this extension of the railway system. The numerous European workmen, and the intelligent professional officers, employed on, or placed in charge of, the railway works, possess the means, which they employ to great advantage, of promoting material and intellectual improvement, and the railway itself is, perhaps, even less a novelty and an advantage, than the amenities of social progress which it is the means of introducing. Already in the vicinity of the chief stations, and especially near those on each side of the Nile ferry, an improved class of houses has been introduced: and, in short, a predominance of European modes and manners is brought under the frequent inspection of railway travellers in Egypt; and as these, generally speaking, are likely to be the more active, opulent, and influential of their respective classes, it is so much the more favourable for the extension of these beneficial influences.

In the railway journey from Alexandria to Kaffre Lais, the attention is divided between the fine lake scenery, resembling an inland sea, and the towers and minarets of Alexandria, which are visible for a great distance. For about 7 or 8 miles on every side, there is a wide expanse of level country, formed by the delta of the Nile, and consisting of a great depth of the finest loam, the fertility of which is maintained by artificial supplies of water.

Even under present circumstances, it is rich and luxuriant, and under more favourable conditions for the application of skill and capital, it is probable that not only a numerous population might be maintained, but that there would be a large surplus of agricultural wealth. Vast tracts of corn, cotton, and other products give an aspect of fertility to the surface of the cultivated lands. The appearance of the numerous native villages which are passed is bleak and dismal. They seem an incongruous mass of dark and miserable hovels, or mud huts. An exact idea of the appearance and want of comfort of the dwellings may be formed, from a series of photographic views by Mr. Lee, R.A., which illustrate the scenery and operations of the railway, and more especially exhibit, in detail, the several aspects of the ferry across the Nile. On approaching Kaffre Lais, the waters of the Nile are presented, as a new and striking feature of the level landscape. At this place it bends in a horse-shoe form, of about 3 miles in length, the railway passing along the middle part of the inner and included tongue of land, which is little more than a mile in width. In the middle of this curve of the river, the railway terminates on its western bank at Kaffre Lais, and commences again on the opposite bank at Kaffre Azzayat, the connection between these places being made by the steam-ferry, which is the subject of this Paper. The distance between the fixed platforms, at the opposite sides of the river, is 1,100 feet.

Ferry-boats guided by chains are in use in many parts of England, and were first adopted, on a large scale, by the late President, Mr. J. M. Rendel.[1] In the present case, it was requisite not only to provide for certain peculiarities of the River Nile, but to comply with financial and other local arrangements, which for a time prevented the erection of so capacious a bridge, as was necessary to establish a complete and uninterrupted communication. The progress of the railway system, and the more enlightened views now entertained, have, however, since led to the adoption of a fixed bridge, which is in progress of construction.

The first and somewhat distant view of the ferry gives a spectator the impression of a huge square tower, floating on the waters of the Nile; its solid contents nearly approximating to those of the Norman keep of the castle at Newcastle-on-Tyne. Its length is 80 feet, its height about 60 feet, and the width of the boat at the bottom is also 60 feet. It is worked by two steam-engines, each of about 15 H.P., placed horizontally, one on each side, and their

[1] A description of the Torpoint Floating Bridge is given in the Minutes of Proceedings Inst. C. E., vol. i. (1838), pp. 21–24; and in the Transactions Inst. C.E., vol. ii., pp. 213–227.

united power suffices to take this gigantic framework, and its railway-load of carriages and passengers, across the Nile in six minutes. Its general form is that of a huge parallelogram of iron framing, supported by iron buttresses from the projecting sides of the boat. The peculiarity of this construction arises from the necessity of adapting the floor and rails of the platform, which receives the railway-train, to the ever-varying elevation of the surface of the river, which has a vertical range of about 27 feet, but changing a few feet in extreme height in different years. By an ingenious, but simple, application of screws, more particularly described hereafter, the platform of the ferry can be easily raised, or lowered, as occasion may require; and this, as well as the adjustment of the rails, is accomplished with great facility. In England, or indeed in Europe generally, or in North America, no limits are placed to the inventive genius of an engineer, by any considerations as to the ability of the workmen to conduct the operations required for mechanical arrangements; but in Egypt, where strong prejudice, as well as considerations of economy, rendered it essential that unskilled native labour should be applied, it was desirable to combine, if possible, superabundant power, with great simplicity of construction. In this case, the Arabs, with the rapidity and dexterity already noticed, conduct the several manipulations, with the utmost ease, and placing themselves simultaneously at the capstans, readily perform their task according to instructions. These men receive for daily wages a sum equal to about three pence halfpenny or four pence of English money. Active and willing, when well directed, in specific duties, such as raising, or lowering the platform, or placing the engines and carriages upon it, they have a large portion of the day unemployed.

The passage is effected with great facility and comfort. Many of the passengers remain in the carriages, where they can see, or know little, except that they are by some, and to them invisible, means, carried comfortably across the river. It is from having witnessed the actual performance of the ferry, under circumstances which afforded ample leisure for its examination, that the Author has been led to attempt the present account of it, and of the concomitant, and, in many respects, peculiar circumstances connected with it. He saw it pass and repass on several occasions, with such smooth and steady motion,—such perfect ease and accuracy, and with all the arrangements of so manageable a character, that it was impossible not to feel gratified, by the satisfactory issue of so singular an engineering work. As he stood on the shores of the Nile, and viewed this ready means of transit, for very ponderous loads, he could not but reflect on the variety, as well as the soundness of the knowledge, which must necessarily

be brought to bear on works of magnitude in foreign countries. Not only is a proficiency in the arts and sciences generally of importance, but in such cases a slight knowledge may prove more dangerous than entire ignorance. The changes of climate, the variations of temperature, the peculiar atmospheric conditions, whether humid or dry, or subject to heavy and sudden rains, or to slow and gradual, but vast inundations, are very different, in England and in Egypt, and yet they have relation to the effects produced, by external causes, on wood and iron. Then again the geological nature of the surface of the country, the supply of materials, and the peculiar form and depth of the yearly deposits of the Nile mud in the channel, or sides of the overflowed river, had to be considered in the selection of a proper site. The requisite adjustments could only be determined, by an accurate regard to the hydrography of the Nile. The construction, at Newcastle, of a work which had to meet all these various conditions in Egypt, cannot be regarded otherwise than as a most satisfactory example of engineering skill. The ferry had been at work upwards of six months, when the Author first saw it, and during that time it had realized all that could be expected.

The Author has now endeavoured to convey such a general idea of the ferry, and of the railway incidents immediately connected with it, as could be derived from passing visits, during a brief stay in Egypt. Since his return, he has been favoured by Mr. Stephenson with access to the original plans, sections, and specifications of the construction, from which the following further details of the jetties and ferry are drawn up.

The jetty at Kaffre Lais is 660 feet in length; that on the opposite shore, at Kaffre Azzayat, is 292 feet in length. They both consist of timber-framing, supporting platforms, and are placed on foundations formed of Mitchell's screw-piles, the framework being braced together, by rods and timber walings. On each platform is a single line of railway, branching into two lines at the ends next the river, so as to permit four carriages being placed on each side of the ferry platform, or eight carriages each transit. Additional support and steadiness are given to the extremity of the jetties, by wrought-iron cylinders, 5 feet in diameter, which were sunk by the pneumatic process. The several mechanical arrangements of the Nile-ferry are directed to facilitating the placing on the platforms the engines and carriages, as well as the passengers, to be conveyed upon it; to provide sufficient power for taking the ferry and its ponderous load across the river, in a direct line from one jetty-head to the other; and so to arrange the level of the ferry-platform as to enable it to coincide exactly, at all times, with the line of the rails at each side of the river,—the variation of level in the waters

of the Nile ranging to an extent of 27 feet between the high and low Nile.

The massive frame rests on a flat-bottomed and shallow barge, of oblong form, in fact a parallelogram with the corners taken off. No attempt was made to give it the form of a ship, the only object being to provide a good floating base for the stages and machinery. The framework of this barge is entirely of wrought-iron, consisting of eight transverse main ribs, each 2 feet deep, turned up at the ends against the sides of the vessel, and two longitudinal ribs, each 1 foot 10½ inches deep, extending from end to end of the vessel. The transverse joints of the plates are covered inside by T-iron ribs, and outside by cover-plates; the longitudinal joints being sheathed also with plates. Extra ribs are placed at the corners to suit the shape. Upon the ribs of the boat, as above described, is erected the framework which contains the moveable platform. The stancheons correspond in number, and in position, with the transverse ribs of the barge. They are 1 foot 6 inches wide at the top, and 1 foot 9 inches at the bottom, spreading to 3 feet at the base. Each of these stancheons, with the exception of those at the four corners, has, on the outer side, a diagonal brace, forming a sort of flying buttress, resting on the turned-up ends of the cross ribs of the boat, an arrangement which adds to the appearance, as well as to the strength, of the structure. The stancheons are strengthened by horizontal beams, 11 feet 9 inches apart, extending between them, the panels thus formed being further strengthened by diagonal bracing. The whole is surmounted by a rigid platform of timber, covered with planks 3 inches in thickness, forming a deck the entire size of the framework, at an ultimate elevation of about 60 feet above the water. Intermediate between this deck and the boat is the moveable platform already mentioned; this is composed of eight wrought-iron beams, one being opposite to each stancheon of the outer frame. The beams are each 1 foot 9 inches deep in the middle, and 1 foot at the ends, and are connected, by a longitudinal plate, with angle-iron at the top and the bottom. This platform is covered with two thicknesses of planking, each 3 inches in thickness, having a double line of rails, on longitudinal sleepers, which exactly correspond with the forked extremities of the railways on the jetties.

The Author has already adverted to the ease and simplicity with which the vertical movement of the middle platform is accomplished by the Arab labourers. The means by which this movement is effected will now be described. To the front of the stancheons, there is a cast-iron frame, extending from near the bottom of the boat to about 20 feet below the top of the great frame. This frame has three vertical recesses, the two outer ones having teeth cast in them, at intervals of 6 inches, so as to form racks. These

racks are fixed, so that the teeth of one rack are opposite the spaces between the teeth of the other. In the middle recess is a wrought-iron ladder, with wrought-iron rungs at intervals of 3 inches. This ladder is of the same length as the racks, and moves freely up and down in the central recess, being fixed at the top to a rod, which reaches to within 4 feet 6 inches of the upper platform. The top of this rod branches into two rods, and these terminate with a brass screw-nut. Working into this nut is a screw, 1 foot 9 inches long, attached to the lower end of a vertical spindle, which passes through the timber deck, and is there turned by a capstan-head, on the top of a hollow iron standard. The platform on which the carriages and passengers are placed rests upon beams corresponding with the stancheons. At each side of these beams, or bearers, of the moveable platform, there is placed a strong bolt, which slides in a cast-iron socket, and is so arranged as to work easily into the rack-like recesses above described. At the end of the beam is a strong rod, jointed at the bottom and terminating at the top in a hook, so as to lay hold of the rungs of the ladder. By following the sequence of these arrangements, it will readily be seen, that whilst one man stationed on the moveable platform works the bolts and adjusts the hooked rod, another on the upper platform can turn the screw, and thus the process of raising, or lowering, the middle platform is readily effected by steps of 3 inches—that being the interval formed by the alternate racks; but as even this is not an adjustment of sufficient nicety for the meeting of the rails of the jetty and platform of the ferry, the last length of rails on the jetties is placed on a hinged platform, and an exact coincidence of level is thus obtained.

It will readily be understood, that the lifting process, by means of the hooked rod, can only be carried to an extent of 21 inches at each operation—that being the length of the screw. The hook is then unfixed, as soon as the bolts are shot into the rack, and the moveable ladder in the middle recess is again raised, or depressed. In practice, it is seldom that an elevation, or depression, of more than a few inches is required, the rise, or fall of the waters of the Nile being gradual, and any considerable change is rarely necessary, between the times of passing trains. An arrangement is made, by which a simultaneous action of the capstans is effected, and this is of no small consequence in an operation where unskilled labour is employed. By this means all irregularity of action in the platform is avoided, and a uniform movement is safely effected.

It may be observed, that the cylinders, at the ends of the jetties, are covered with strong timber, and being adjusted to the form of the boat, a wedge-like action is produced, and the boat, with its

framework, is brought into an exact horizontal position. When necessary, the adjustment is facilitated, by means of crabs, placed at each corner of the small decks.

The adaptation of chains as a guide and means of applying motive power is so well known, that it is unnecessary to describe the arrangements otherwise than in general terms. Care has been taken to guard against the impediments to which this system is liable, and in this case it was the only one which was applicable for the purposes required. The two chains are 28 feet apart, and pass just outside the stancheons; the links are 5 inches long, $3\frac{1}{2}$ inches across, and are formed of iron $1\frac{1}{8}$ inch in diameter. The two wheels which act upon the chains are worked by two high-pressure engines of 15 H.P. each, placed one on each side of the boat, and as low as possible. Being outside the stancheons of the central frame, and within the flying buttresses, they are quite out of the way of the moveable platform, which, during the periods of high Nile, has to descend to the level of the ribs of the barge. The engines are connected by a shaft extending across the boat. The speed of the engines is decreased by toothed wheels and pinions, twelve strokes of the engine giving one revolution to the chain-wheels, which are of cast-iron, 9 feet in diameter to the centre line of the chain, with the rims notched so as to bite each link both sideways and at the bottom of the channel. Each notched rim is cast in several pieces, so that any piece may be replaced, in case of breakage, a precaution which has only in one instance proved needful, and that under circumstances of palpable neglect on the part of the engine-driver. Guiding-channels are provided, by which the passage of the chain is facilitated, and all injury to the boat is avoided. The engine-rooms are of simple construction, and the flat tops are frequently used by passengers as decks to walk on, when the difference of level between the moveable platform and these fixed decks happens to be only a few feet.

The greatest depth of water likely to be drawn by the barge and ferry is 3 feet 6 inches when loaded, and about 3 feet when unloaded.

In conclusion, the Author begs to express his acknowledgments to Mr. Stockman, Assoc. Inst. C.E., for the care and skill exhibited in the several illustrations (from which Plate 2 has been compiled), and for the measurements and details obtained from the plans and sections, which the Author has condensed, in order to bring this Paper within the limits of a general account of this interesting work. Nor can he neglect to express his obligations to Mr. Stephenson, for the full explanations on the occasion of his visits to the Nile ferry. He has endeavoured to convey to others, some portion of the interest with which he witnessed its performance; and he feels assured that, however imperfectly he

may have succeeded, he will have no difficulty in obtaining the concurrence of the Members, in the wish, that as the designer of the Nile ferry is now about to close the period of his Presidency, it may still be their good fortune, for many years, to derive instruction, as well as pleasure, from the study of the works which he has already executed, and it may be hoped is yet to bring into successful operation.

[Mr. SOPWITH

Mr. SOPWITH said, in giving an account of any mechanical, or engineering work, situated in Great Britain, or in those parts of the Continent which were readily accessible, he should have confined himself to a description of the work itself, because the adjuncts of scenery, and other circumstances attending it, would be comparatively well known, or be easy of observation, so that it would not be necessary to allude to them. But the case was very different in Egypt; and as this was the first railway ever made in that country, he thought he was justified in endeavouring to give a general idea of the local peculiarities, both in regard to the country itself, and to the mode of execution of such works by means of native labour.

Mr. G. W. HEMANS said, it would be interesting to be furnished with some further information as to the mode of sinking, and the diameter of, the cylinders, and as to the cost of the whole structure. He had made an unsuccessful attempt to sink some cylinders, 10 feet in diameter, through a bed of homogeneous clay, by Potts' pneumatic process, but could never get a vacuum of more than 15 inches of pressure. At last he effected the operation, by excavating below the cylinders, and pressing them down by weights imposed upon the top.

Mr. GREAVES thought the floating-ferries, or bridges, designed by the late Mr. Rendel, and referred to in the Paper, would, in some respects, bear comparison with that now under discussion. The dimensions of that at Portsmouth were, length 84 feet, and breadth 60 feet, with a draft of water of 4 feet 6 inches. A similar ferry-bridge, constructed afterwards, for Calcutta, was 84 feet in length and 64 in width, with a draft of water of 3 feet 6 inches. It was desired to have a draft of water of only 3 feet, but owing to the weight of the apparatus, it could not be kept so low. The chains were in both cases heavier than those of the Nile ferry; in the former the links were formed of round iron, $1\frac{1}{2}$ inch in diameter, and in the latter of iron $1\frac{7}{10}$ inch in diameter. It had been found, that more power was consumed in overhauling the chains, than in overcoming the resistance of the water. The difficulties with the Portsmouth ferry were, to prevent the ends of the chains from breaking away, owing to the force of the stream, and to counteract the effects of the constantly-recurring tides, which in the case under discussion had not to be contended with, the rise and fall of the water being only periodical. In the Portsmouth bridge, the chains radiated from a point a little above high water. Platforms, long enough to reach the shore, were hinged to each end of the bridge, forming easy inclines of communication for vehicles and foot-passengers, and allowing for a considerable amount of leeway, which would always occur, to a

certain extent, where there was a tide, or a flow in any particular direction. The plan under discussion did not appear so suitable for the traffic of foot-passengers, carriages, and horses, although it satisfied the requirements of the railway. He hoped the introduction of this system on the high road to India would lead to its more extended use there and elsewhere. He had urged upon the authorities of the East India Company, that this plan was eminently suited to the wants of that country, for the passage of many of its rivers, as fixed bridges were not in all places applicable; and by this system a passage might in many cases be effected for a tenth of what a permanent structure would cost. He trusted, when tranquillity was restored, that these and other similarly useful works would be authorised by Government.

Sir JOHN RENNIE observed, that there was no analogy between the ferry now under discussion, and the floating bridges introduced by the late Mr. Rendel, to whom great credit was due for the application of steam to these purposes. In the present case, the difference of level between the railway, which was necessarily fixed above the general surface of the country, and the river, which was variable, was constantly changing, so that a moveable platform to communicate between the two was indispensable, and which, by the plan adopted, was well effected; whilst in the other case, the difference of level was not nearly so great, the road being formed on the natural surface of the ground, or river bank, so that vehicles and foot-passengers could pass from the land to the bridge, by means of a short incline.

Captain MOORSOM remarked, that he had crossed the Nile ferry twice, and on each occasion there was a delay in the starting of the trains from the opposite shore, of from an hour and a half to two hours. He admitted that the Arab arrangements were very slow; still he thought in the transport of a train across the ferry, in detachments of eight carriages, each passage must occupy at least thirty, or thirty-five minutes, as the trains ordinarily consisted of from twenty to twenty-four carriages. He did not believe that English ingenuity would be able to reduce this more than five, or ten minutes. He should be sorry if such detentions arose from the employment of English skill and capital in India. He understood, in the present instance, that the ferry was to be superseded by a permanent bridge, which would cause a saving of an hour and a half, or two hours in a journey of only seven hours.

Mr. R. STEPHENSON, M.P., President, remarked, that the jetties on each shore of the Nile were carried on Mitchell's screw-piles, with protecting cylinders at the extremities. These cylinders were sunk by the compressed air process, or by using a 'plenum' instead of a vacuum, as had been first adopted, he

believed, by Mr. Hughes, M. Inst. C. E., at Rochester bridge.[1] This plan had been previously employed, with success, for the foundations of a bridge over another branch of the Nile, where a failure had originally occurred, owing to the piles having only been sunk 25 feet. The bed of the Nile consisted of an alluvial deposit, extending to a depth of from 60 feet to 70 feet, and possessing no adhesion. When high Nile came, in the following season, after the erection of the bridge, in consequence of the slight obstruction offered by the piles, a scouring action took place, which undermined the piers, and rendered them so unstable, that they had to be rebuilt. Mr. Hughes' pneumatic process was then adopted, as previously mentioned, and as an additional security, large rubble stones were thrown round the piers, so as to form a dam, to protect them from the violent scour. In building a bridge, at Anglesea, on the Chester and Holyhead railway, he had known hollow piles 12 inches in diameter to sink down bodily through a bed of sand. The mode of attaching the chains on the two shores of the Nile, was by having weights rising and falling within a cylinder, at each extremity, to compensate for the drag upon the chains. The plain parallelogram form had been adopted, because it was the best for giving great floatation, with the least draft of water, and affording that stability which was so necessary, when the weight was at times raised high above the surface of the river, as at the times of low Nile. Speed was not an object, when the passage could be effected in six minutes, which, in a line of 140 miles in length, was a mere fraction of the duration of the journey. The total cost of the ferry, including the jetties, amounted to £18,000.

In the construction of the ferry, great credit was due to the late Mr. C. H. Wild and Mr. Dempsey for the details of the machinery; to Mr. George Robert Stephenson for the method of lifting the platforms; and to Mr. Rouse and Mr. M'Laren for putting together and erecting the whole, and making it work so thoroughly well.

Mr. Stephenson remarked, that the rate of the current of the Nile, which was in one direction only, varied according to the height of the water, sometimes approaching, at high Nile, and during the prevalence of strong winds, to 5 feet per hour. It was, therefore, certain that the vessel in its passage across would deviate from the right line; and that, in order to bring it square against the end of the jetty, so as to get the carriages off the platform on to the railway, an exertion of force would be necessary. It was thought, at first, that by having a clutch in the centre of the main shaft, one of the engines might be employed to bring up the boat

[1] *Vide* Minutes of Proceedings Inst. C. E., vol. x., pp 353–365.

to the right line. But, on reflection, it was at once seen, that the power to be obtained by one paddle-wheel was quite inadequate for the purpose. Therefore, the plan was adopted, as stated in the Paper, of having a barge moored on the upper side of each pier, capstans being fitted on the pier and on the barge to bring the vessel up.

Before settling the design, the floating-bridges invented and constructed by the late Mr. Rendel, at Plymouth and at Portsmouth, were carefully studied, and the parts most suited for the conditions of the Nile-ferry were copied. These conditions were, however, so peculiar, that they rendered necessary a design of an entirely novel character, in which it was imperative to guide and control the passage across a rapid river, with such precision as to bring the extremities of the rails together, to allow the heavy railway carriages to pass without difficulty. Such conditions were very different from those of floating-bridges, on to which road carriages were drawn by their own horses, or were easily pushed by a few men, and of passengers, who walked on board and on shore again. Thus, no parallel could be established between the two adaptations of the same principle.

Objections had been raised to delays which had occurred at the ferry, but these were entirely due to the obstinacy and want of practical knowledge displayed in the general arrangements for the goods and passenger traffic of the railway,—defects which, in fact, pervaded everything in Egypt—and not to any imperfections in the construction of the machine, or in the manner of working it. It was for some time the custom, on the arrival of the train at the ferry, to make the passengers alight from the carriages, to put them into a steam-boat, convey them across the river, and oblige them to climb up the muddy banks to rejoin the railway carriages, which had meanwhile been conveyed across, by the steam ferry, in "empty grandeur." This was only equalled by the too common custom of obliging thousands of "fellahs" and their families, carrying all their worldly gear with them, when on their compulsory migrations as labourers on Government works, to walk, for days, parallel with the railway, along which they could have been so cheaply, and certainly more humanely conveyed. If the human race was not much considered in the Egyptian railway arrangements, the goods-traffic was not more attended to, when cotton, which could be carried for two pence per ton, was charged fifteen pence, in order to force it to be still brought down by the Nile boats. As an illustration of the mode of management of the line, he might state that, at one period, there was only one train each way every other day, although the natives had evinced a great desire to travel, and the line connected towns containing large populations. He hoped that contact with the

energetic engineers, in the service of the Pacha, would in due time break down such dilatory habits and perverse adherence to antiquated customs, and that the benefits anticipated from the establishment of the railway would be realized.

It had been said, that these steam-ferries were not applicable to the rivers of India, and that it was undesirable for the Institution to appear to recommend the system generally. To this it might be replied, that good engineers did not adopt, or apply systems of this kind indiscriminately, but used special machines for the situations to which they were best fitted. The objections to the employment of these steam-ferries, as not being adapted to the rivers of India, might easily be shown to be ill-founded. It had not been contemplated to use them on the numerous small rivers, or on those which became torrents during the rainy season, and were dry during the summer. But the system was well adapted for very wide rivers, where there was always plenty of water, and where the construction of permanent bridges would be disproportionately expensive, in this early stage of Indian railways.

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